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Lehmann's; the two perhaps had the same number-habit. Does Professor Titchener seriously think that a number-habit in a guesser can account for the amount of coincidence between the numbers which he guesses and those upon counters drawn at random out of a bag?

Even in anti-telepathic Science accuracy of representation is required, and I am pleading not for telepathy, but only for accuracy.

WILLIAM JAMES.

ON THE WEHNELT CURRENT BREAKER.

TO THE EDITOR OF SCIENCE: The following facts, noticed while experimenting with the Wehnelt electrolytic current breaker, may be not without interest:

In order to test if the action of the breaker could be due to a spheroidal state, produced by the high temperature of the positive electrode, some means for measuring the temperature of this electrode had to be obtained. For this purpose I used electrodes of fusible metals melting at different temperatures, the temperature of the electrode being necessarily less than that at which the alloy melts, if the latter remain unfused. In this way one can at least obtain the superior limit for the temperature of the electrode. Starting with a fusible alloy which melted at about 78° C., the electrode melted as soon as the circuit was closed. The next metal used melted at 96° C., and was fused an appreciable, though very short, time after the current was established. Finally, using an anode made of a metal which melted at 168° C., no indication of fusion of the electrode could be detected, even after the breaker had run for ten minutes at a time. This seems to show that the temperature of the electrode was far below 200°, the temperature necessary, at atmospheric pressure, for the production of the spheroidal state.

The influence of self-induction on the action of the breaker was also studied, to some extent. Diminution of the self-induction in circuit diminishes the period of the action, as is shown by the heightened pitch of the sound produced. But absence of all self-induction prevents wholly the working of the breaker. The cell was used in a circuit composed of a storage battery, non-

inductive electrolytic resistances and wires wound non-inductively. With this arrangement no interruption of the current could be produced, though the electromotive force was raised to thirty volts and the current to eighteen amperes. As soon, however, as a coil with self-induction was put in the circuit the action of the breaker recommenced. Induction in the circuit is essential to the action of this form of interrupter.

HOWARD McCLENAHAN.

PHYSICAL DEPARTMENT, PRINCETON UNIVERSITY.

THERMODYNAMIC ACTION OF 'STEAM-GAS.'

ONE of the most valuable papers recently published in the fields of applied science is that which has just been reprinted from the *Revue de Mécanique* of the last year, the work of Professor Sinigaglia, a well-known author in that field.*

This is the latest and, in many respects, the most complete discussion of a supremely important subject; one to which the minds of men of science and engineers the world over are now again turning after a period of many years, during which the thermodynamic promise of gain in efficiency in the steam-engine through the conversion of a vapor into a gas by this process of superheating had been almost universally believed to be more than counterbalanced by the very serious difficulties met in the earlier days in the attempt to profit by it. Changes have taken place during the last generation which are now thought by many authorities to have largely reduced the obstructions formerly seemingly fatal to a great thermodynamic advance.

In the practical thermodynamic operation of the steam-engine, as M. Bertrand has remarked, there is no such thing as 'saturated vapor,' as that term is customarily employed by the thermodynamists. The working fluid is always, in fact, a mixture of vapor and its liquid, in a

*Application de la Surchauffe aux Machines à Vapeur par M. François Sinigaglia, Professeur agrégé des Ingénieurs de Naples; Ingénieur-Directeur de l'Association des Propriétaires d'Appareils à Vapeur dans les Province napolitaines. Extrait de la *Revue de Mécanique* (1897-98); Paris, V^eve Ch. Dunod, Éditeur, 1898.

state of instability as to quality. The investigations of the '*théorie générique*' made by Rankine, Clausius, Zeuner and others resulted in establishment of no rational expressions for the actual heat-exchanges of the real, as distinguished from the ideal, engine, and Hirn's '*théorie expérimentale*,' as developed by that great investigator and his disciples, is still the only resort of the student of the curious extra-thermodynamic processes accompanying the thermodynamic operation of the engine.

Superheating has come to be looked upon, not as method of giving superior thermodynamic action, but as simply a provision for reducing internal wastes due to heat-exchanges between the steam and the metal surrounding it. Its effectiveness was recognized as early as Trevethick's time (1828 or earlier) and became well understood about the middle of the century; since which time numerous inventions have been made, looking to its utilization, few giving any promise of success. The Alsatian school has revealed very completely the method and the effect of its adoption, and it has come to be well understood that its province is simply to reduce that form of waste known as 'initial condensation' or 'cylinder condensation.' Its successful use would effect the suppression of those losses in such manner, in the words of Dwelshauvers-Dery, as to give maximum efficiency by securing the exhaust of the steam from the engine in the dry and saturated condition. This is, in his opinion, the practical criterion of most perfect action. The actual gain has been found by Hirn to be, in several cases studied by him experimentally, from 20 to nearly 50 per cent., with a superheat amounting to from 210°C. to 245°C. The nearest approximation yet reported to the ideal, purely thermodynamic, case has been effected by this means—particularly, of late, by Schmidt.

The failures of the past have been due to difficulties in securing an apparatus which cannot be rapidly injured by excess of heat in presence of superheated vapor of water, and a system of lubrication of the cylinder and piston capable of working satisfactorily at the temperatures attained in effective superheating. The latter obstacle is now overcome, largely, by the use of the high-test mineral oils; the former

remains a serious obstruction. The increasing steam-pressures of our day also reduce both the need and the availability of increasing superheat.

The results of successful superheating exhibit themselves both at the engine and at the boiler, and, as with multiple-cylinder engines, the gain at the boiler in economical employment of fuel is greater than that at the engine through a more perfect thermodynamic action; for the reduction of the demand for steam at the engine results in an increased economy in the production of such steam through the larger proportion of heating surface to weight of steam produced. Thus a gain of 20 per cent. at the engine may be accompanied by a gain of 22 per cent. or more in fuel as measured at the boiler. The desirable amount of superheat is that which will prevent the condensation of the vapor entering the steam-cylinder and insure its rejection as saturated vapor at exhaust.

The apparatus employed by various inventors and investigators in this field, from 1850 to our own time is described at considerable length by M. Sinigaglia, and the results of experiment are recited. In many instances, recently, particularly, it is reported that no serious inconveniences were met with in the application of this system; in other cases much trouble and sometimes serious accidents resulted, due to the 'burning' of the apparatus and its yielding, thus weakened, to the pressure. Messrs. Ludwig and Weber obtained, in an extensive series of experiments in Alsace, some very encouraging figures. An average gain of 7.5 per cent., net, was secured by moderate superheat (44°C.). Messrs. Walther-Meunier, and Ludwig, later, reported a gain of 13 to 15 per cent. from a superheat of somewhat greater amount. Schwoerer obtained a gain in efficiency of 15 to 18 per cent. by superheating 68°C. Hirsch reports similar figures from an equal amount of gasification in a marine apparatus. Schroeter obtained gains of 10 per cent. and more in a very elaborate and detailed investigation, in which the superheat amounted to 60°C. The most remarkable results reported are those of Schmidt, who, by adopting an enormous portion of superheating to heating surface (six to one), secured a superheat of 190°C., and at another time, with a

comparatively small apparatus, secured the highest record yet established. With another engine a gain in weight of steam supplied the engine amounting to nearly 40 per cent. was effected, and in weight of fuel 28 per cent; the difference being due, obviously, to the fact that each unit-weight of steam carried an abnormal quantity of stored heat.

Professor Sinigaglia concludes :

1. Superheating vapor is irrefutably proved to be the most effective system of reduction of internal wastes of heat in the steam-engine.

2. The higher the degree of superheating attainable, the nearer does the thermodynamic result approximate that indicated by pure theory and by the formulas of thermodynamics.

3. From the industrial point of view, it is necessary to note the gain, not at the engine, but in fuel demanded at the boiler, and the apparatus of vaporization and of gasification must be efficient and durable.

4. The final test is in the study of the financial aspect of the operation.

“Mais, aujourd’hui, les installations nombreuses de l’Alsace et de l’Allemagne ont donné des résultats si remarquables qu’on finira par vaincre les dernières difficultés qui s’opposent à une application générale de la surchauffe aux machines à vapeur. Ce sera le meilleur hommage rendu à Hirn et à son école.”

R. H. THURSTON.

THE REMOVAL OF DR. WORTMAN TO THE CARNEGIE MUSEUM.

DR. J. L. WORTMAN, of the American Museum of Natural History, has been called to take charge of the new collections of Vertebrate fossils in the Carnegie Museum at Pittsburgh, and has resigned his position in the American Museum in order to enter upon his new duties. The finest portions of the Cope collection of Fossil Mammals were made by Dr. Wortman previous to his connection with the Army Medical Museum in Washington. Since 1890 he has had charge of most of the parties sent out from the American Museum for Fossil Mammals and Reptiles and has conducted these explorations with extraordinary success. A very large part, therefore, of the collections in the Department

of Vertebrate Paleontology are due to the energy and intelligence of Dr. Wortman and his assistants in the field. His field work has been carried on almost exclusively during the summer months, and he has been occupied during the winters in the preparation of a series of bulletins based chiefly upon the field collections, many of which have attracted wide attention. Notable among these are the papers upon the Skeleton of *Patriofelis*, the Anatomy of *Agriochærus*, the revision of all the early species of horses, and a geological paper upon the Stratigraphy of the White River Beds. The most important of his original contributions in the series is, however, that upon the ‘Origin of the Sloths,’ based chiefly upon the fortunate discovery of the foot of *Psittacotherium* in the Torrejon beds of New Mexico. Dr. Wortman’s latest paper, now in press, is upon the Ancestry of the Dogs, in which he successfully demonstrates the direct phylogenetic relationship between the Canidæ and of certain dog-like Creodonts.

Dr. Wortman’s services to the Museum are greatly appreciated and his resignation has been accepted with much regret. He carries with him the best wishes of his friends for his success in his new undertaking.

H. F. O.

SCIENTIFIC NOTES AND NEWS.

PROFESSOR F. L. O. WADSWORTH has been appointed by the managers of the Western Pennsylvania University, Director of the Allegheny Observatory, succeeding in the position Professors Keeler and Langley. Professor Wadsworth has been connected with Yerkes Observatory since its opening and was previously at the Astrophysical Observatory of the Smithsonian Institution.

UNDER authority of the Secretary of the Treasury, the Superintendent of the Coast and Geodetic Survey has effected a reorganization in that Bureau in such a way as to relieve the head of the Bureau of a certain amount of the routine work and to insure also a more direct supervision of the field work. The following officers have been appointed: Assistant Superintendent, Mr. O. H. Tittman; Assistant in charge of the Office, Mr. Andrew Braid; In-